DOCUMENT RESUME

ED 356 897 PS 021 367

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TITLE Domain Knowledge and Analytic and Holistic Category Learning in Young Children.
PUB DATE Mar 93
NOTE 16p.; Paper presented at the Biennial Meeting of the Society for Research in Child Development (60th, New Orleans, LA, March 25-28, 1993).
PUB TYPE Speeches/Conference Papers (150) -- Reports - Research/Technical (143)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Classification; *Cognitive Development; *Cognitive Processes; Cognitive Tests; Kindergarten; *Kindergarten Children; Primary Education; *Prior Learning
IDENTIFIERS *Analytic Approach; Attribute Identification; Categorical Perception; Category Knowledge; Domain Knowledge; *Holistic Processing

ABSTRACT

To examine the link between analytic and holistic modes of processing and the amount of domain knowledge, 2 category-learning studies were conducted with 5-year-old children. In the first study, 26 kindergarten children were classified according to their verbal knowledge about plants and their familiarity with flowers. They then performed a categorization task using two invented categories of flowers. The categories were constructed so that they could be learned either by an analytic, single-attribute rule, or on the basis of holistic, family-resemblance relations. Results indicated that regardless of their knowledge about plants or their familiarity with flowers, all children who reached a predetermined learning criterion used an analytic, single-attribute rule to categorize. In the second study, 33 kindergartners performed a categorization task similar to that used in the first experiment; the second experiment, however, used three values per attribute, thus strengthening the overall similarity structure of the categories. Analysis revealed that processing modes did not differ as a function of subjects' prior knowledge. Results from both studies did not support previous research suggesting that greater domain knowledge prompts analytic processing. Rather, these studies indicated that children's categorization performance was predominantly analytic, regardless of domain knowledge. (MM)

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ED356897

Domain Knowledge and Analytic and Holistic Category Learning in Young Children

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PS 021367

Paper presented at the meeting of the Society for Research in Child Development in New Orleans, LA, March 25 - 28, 1993.

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Abstract

Previous research suggests that perceptual processing in children transitions from a phase that is predominantly holistic (guided by overall-similarity relations) to a phase that is predominantly analytic (guided by dimensional relations). In accordance with recent work in developmental psychology that attributes quantitative increases in cognitive performance to the growth of the knowledge base, the research reported in this paper evaluated the general hypothesis that greater domain knowledge facilitates the transition to more analytic processing. For this purpose, two category-learning studies with 5-year-old children (boys and girls of mixed ethnic and socio-economic background) were conducted. Children's categorization performance in these studies was predominantly analytic, regardless of their domain knowledge. The results do not support the idea that greater domain knowledge prompts analytic processing, but emphasize that young children have considerable analytic capacities even early on.

Introduction

According to previous research, perceptual processing in children transitions from a phase that is predominantly holistic (guided by overall-similarity relations) to a phase that is predominantly analytic (guided by dimensional relations) (e.g., Kemler, 1983; Kemler Nelson, 1984; J.D. Smith & Kemler Nelson, 1984, 1988; L.B. Smith, 1989). This developmental pattern raises an important question: what prompts the increase of analytic processing with development? In the past, holistic processing has been attributed to a lack of the cognitive effort, attentional resources, or short-term memory capacities that are needed to carry out the hypothesis testing procedures of flexible analysis (e.g., J. D. Smith &

Kemler Nelson, 1984). Analytic processing was assumed to increase as children's limited cognitive capacities increase. On closer inspection, however, this account turns out to be insufficient, since young children neither lack the ability to analyze, nor the tendency to sometimes use this ability in the service of classification and categorization.

An alternative account that could explain why young children are more analytic learners in some contexts or domains than others, and why analytic processing gradually increases with development, relates to the learner's background knowledge. Over the past few years, an increasing number of investigators have argued that background knowledge or intuitive theories of individuals have an important influence on their conceptual structures and processes (e.g., Carey, 1985; Chi, 1985; Keil, 1989; Murphy & Medin, 1985; Neisser, 1987; Wattenmaker, Nakamura, & Medin, 1988). This work suggests an interesting possibility. Perhaps analytic processing increases in young children as they become more knowledgeable in different domains. The idea that there is a link between analytic and holistic modes of processing and the relative absence and presence of domain knowledge has not yet been empirically tested. The purpose of this investigation was to perform such a test.

Experiment 1

Method

Subjects were 26 kindergartners, boys and girls of mixed ethnic and socio-economic background, with a mean age of 5 years, 11 months. On the basis of a brief interview about plants, a flower recognition task, and a parent

questionnaire, subjects were classified according to their verbal knowledge about plants (high versus low) and their familiarity with flowers (high versus low). There were about equal numbers of subjects in the high and low plant knowledge and flower familiarity groups.

The subjects participated in a standard categorization study in which they learned to sort instances (line drawings) of two invented categories of flowers into two different piles. The categories were constructed in such a way that they could be learned either by an analytic, single-attribute rule, or on the basis of holistic, family-resemblance relations. The categorization task used in this study was adapted from Kemler Nelson (1984, Experiment 1). The general structure of this task is illustrated in Figure 1, and an illustration of representative stimuli is given in Figure 2.

Results and Discussion

Subjects' performance was surprisingly analytic. Regardless of their knowledge about plants or their familiarity with flowers, all of the children who reached a predetermined learning criterion (69% of the subjects) used an analytic, single-attribute rule to categorize the instances. The results of this study are not consistent with the hypothesis that domain knowledge facilitates analytic processing.

The finding that category learning was almost exclusively analytic is inconsistent with evidence that suggests that perceptual processing . . . kindergarten-age children undergoes a transition from being predominately holistic to being predominantly analytic (e.g., see Kemler, 1983 for a review). On the basis of this

Figure 1. Structure of the stimuli used in Experiment 1

Learning Stimuli

Category 1	Category 2
0 0 0 0	1 1 1 1
0 1 0 0	1 0 1 1
0 0 1 0	1 1 0 1
0 0 0 1	1 1 1 0

Transfer Stimuli

Critical Test Instances

0 1 1 1

1 0 0 0

Ambiguous Instances

0 0 1 1

1 1 0 0

1 0 1 0

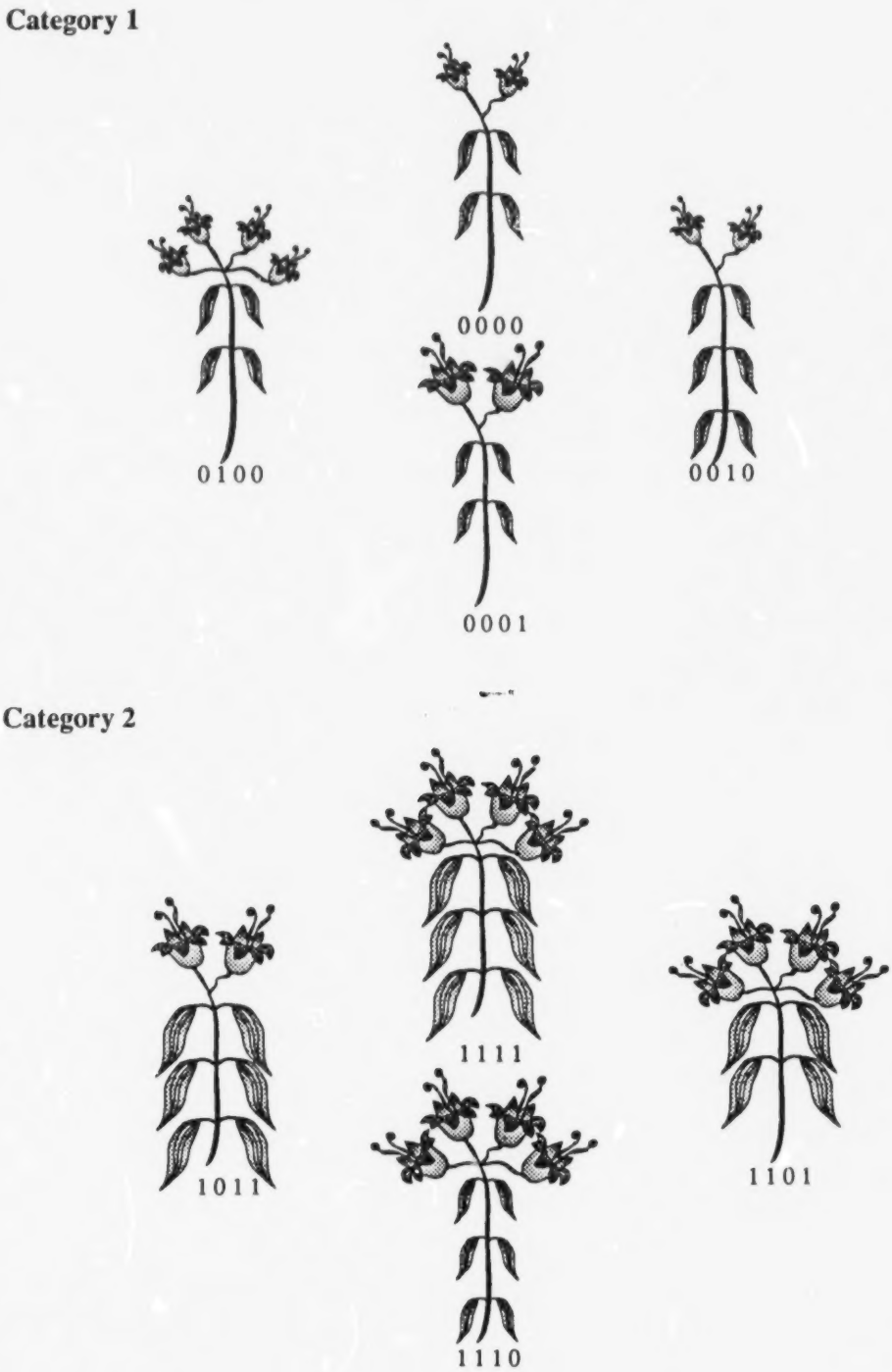
0 1 0 1

0 1 1 0

1 0 0 1

Note: Each row of four numbers represents one stimulus with four different attributes. The numbers represent attribute values (e.g., small (0) and large (1) flowers).

Figure 2. Illustration of represenative stimuli (reduced in size) used in Experiment 1.



evidence, one would expect at least to find both analytic and holistic processing in a population of 5- to 6-year olds. How then can we account for the frequent occurrence of analytic processing in this study? One possibility is that the categorization task discouraged holistic processing since the overall-similarity structure of the categories employed was relatively weak. Experiment 2 employed categories with a stronger overall-similarity structure in an effort to elicit more holistic responding.

Experiment 2

Method

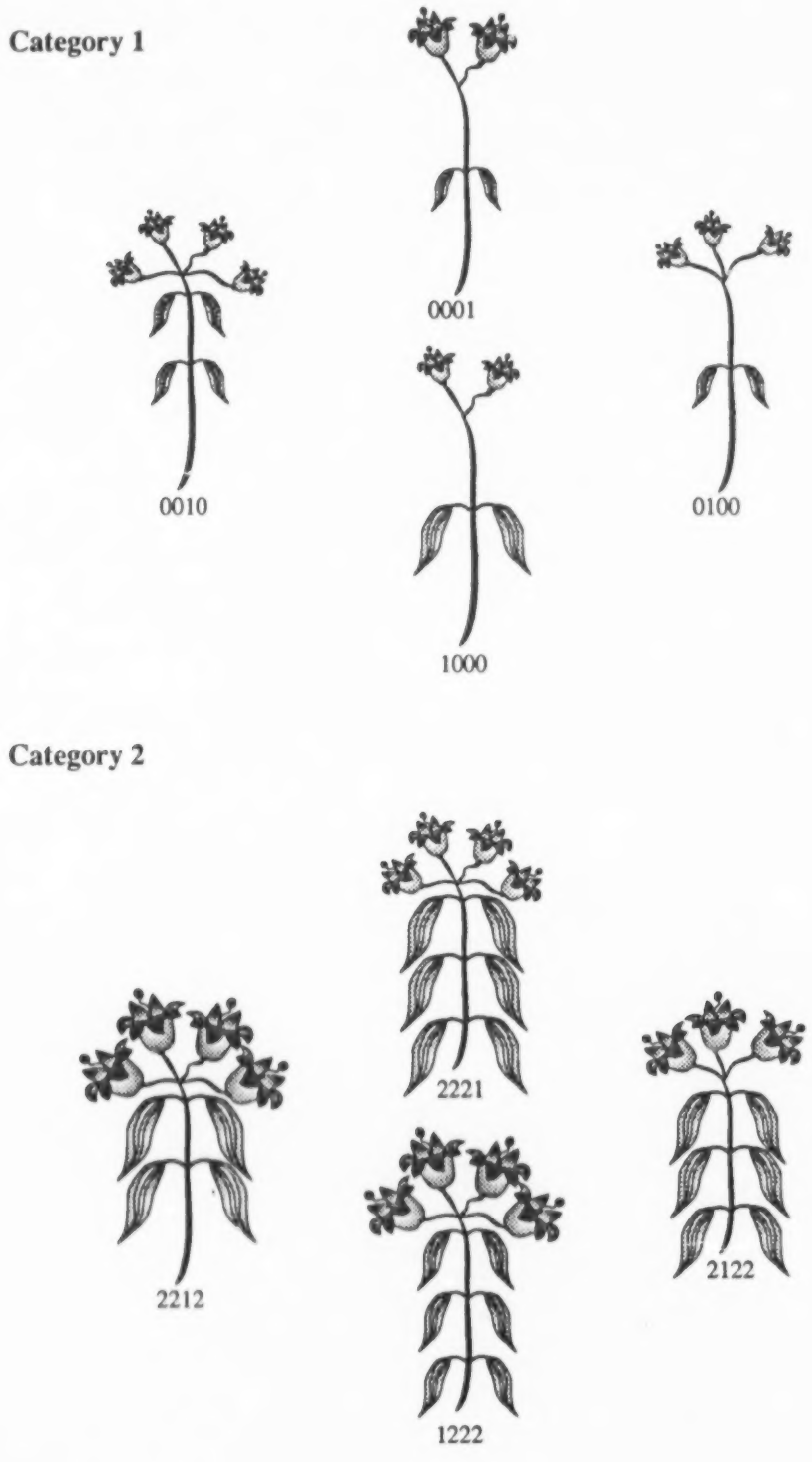
Subjects were 33 kindergartners, boys and girls of mixed ethnic and socio-economic background with a mean age of 5 years, 7 months. Subjects were classified according to their verbal knowledge about plants and their familiarity with flowers as in Experiment 1. There were about equal numbers of subjects in the high and low plant knowledge and flower familiarity groups.

The categorization task for this study was modeled after Kemler Nelson (1984, Experiment 4) and Ward and Scott (1987). As in Experiment 1, subjects learned to sort instances of two invented flower categories into two different piles. Figure 3 illustrates the general structure of the categorization task. Note that by using three values per attribute it was possible to make the overall-similarity structure of the categories particularly strong. That is, compared to Experiment 1, the within-category similarity of instances relative to the between-category similarity was higher. A set of representative stimuli is shown in Figure 4.

Figure 3. Structure of the categorization task used in Experiment 2.

Category 1	Category 2
0001	2221
0010	2212
0100	2122
1000	1222

Figure 4. Illustration of representative stimuli (reduced in size) used in Experiment 2.



Results

Subjects' processing strategies were inferred based on their patterns of classification errors (c.f., J. D. Smith, Tracy, & Murray, in press). The analysis examined the probability of subjects shifting attributes after making an error on an instance that had an intermediate value on the attribute they were focusing on. For each categorization error (beyond the first) that a subject made, it was noted if it reflected a shift to another focal attribute since the last error. If subjects were flexibly focusing on successive attributes (a form of analytic processing), and thus refocused their attention after each error, the ratio of attribute shifts to the number of total errors minus one would be 1.0. By contrast, if subjects were rigidly focusing on one particular attribute (another form of analytic processing) and thus never switched attributes, this ratio would approach 0. And if subjects were paying broad attention to all four attributes (holistic processing), their errors would be randomly distributed over all four attributes and the ratio would be about .75.

On the basis of this analysis, subjects were classified as flexibly analytic learners when their "shift index" (SI) was 1.0, as rigidly analytic when their SI ranged from 0 to .50, and as holistic when their SI ranged from .63 to .83. Table 1 shows the mean SI and the percentage of subjects who were identified as flexibly analytic, rigidly analytic, and holistic learners for each of the plant knowledge and flower familiarity groups. None of the differences in the mean SI between subject groups were significant, and the proportions of the various response types were approximately the same across the different plant knowledge and flower familiarity groups. Thus, processing modes did not differ as a function of subjects' knowledge about plants or familiarity with flowers.

Table 1

Mean Shift Index (SI), and Percent of Flexibly Analytic, Rigidly Analytic, Holistic, and Unclassifiable Learners for the Different Subject Groups in the Family-Resemblance Condition of Experiment 2

		Type of Learner			
Subject Groups	Mean SI[a]	% Flexibly Analytic	% Rigidly Analytic	% Holistic	% Not Classifiable[b]
High Knowledge about Plants	.59	13	25	31	31
Low Knowledge about Plants	.63	24	29	29	18
High Familiarity with Flowers	.68	24	24	41	12
Low Familiarity with Flowers	.51	13	31	19	38
Overall	.61	18	27	30	24

[a] Mean Shift Index for subjects who made more than 1 error

[b] Proportion of all subjects who made less than 2 errors

General Discussion

The results of this investigation are not consistent with the idea that the extent of children's domain knowledge influences the mode of processing that they employ when learning new categories from the domain. In fact, they make a strong case against it. First, children who differed in the extent of their domain knowledge employed the same processing modes. And second, children who did have domain knowledge employed both analytic and holistic processing modes. The results of Experiment 1 alone, which indicate that all subjects, regardless of their domain knowledge, engaged in analytic category learning, would have been inconclusive because they left open the possibility that all children already had enough domain knowledge for them to engage in analytic processing. However, the results of Experiment 2 mitigate against this possibility since some of the children with greater domain knowledge were found to engage in holistic category learning, and some of the children who lacked domain knowledge were found to engage in analytic category learning.

The present results appear inconsistent with previous research that suggests that perceptual processing in children undergoes a transition from a phase that is predominantly holistic to one that is predominantly analytic. According to this account, 5- to 6-year-old children should be in a transitional phase in which both analytic and holistic modes of processing will be observed. The current results, which show a great deal of analytic processing in children of this age range, are in conflict with this particular view of development. There are at least two explanations that could resolve this conflict.

First, it is possible that the results of the current studies overestimate the occurrence of analytic processing in young children, because of the nature of the categorization tasks. The categories employed in Experiment 1 had a weak overall-similarity structure, which should have discouraged holistic processing. In fact, the results of Experiment 2 support this line of reasoning, because by strengthening the overall-similarity structure of the categories to be learned more holistic processing was observed. The fact that a substantial proportion of subjects in Experiment 2 did engage in holistic processing suggests that the occurrence of analytic or holistic modes of processing depends on an interaction between observer factors and the nature of the task.

Alternatively, it is possible that kindergarten-age children are indeed analytic category learners. The frequent occurrence of analytic category learning that was observed in this investigation is consistent with results of a few other studies. Ward and Scott (1987) and Ward, Vela, and Hass (1990) have found strong evidence for analytic category learning in 5-year-old children. However, evidence suggesting that kindergarten-age children engage in holistic category learning is not necessarily inconsistent with the idea that there is a holistic-to-analytic developmental trend in perceptual processing. This is because categorization tasks in general may create a strong set for analysis and selective attention, so that a holistic-to-analytic developmental trend in category learning tasks may begin sooner and end earlier than in classification tasks (c.f., J. D. Smith, 1989). In other words, it is conceivable that children still younger than those who participated in the present studies can be shown to engage in holistic processing in the type of categorization task that was used in this investigation. Further research is needed to distinguish between these alternative explanations.

Acknowledgments

This research was part of a dissertation submitted to the faculty of the New School for Social Research in partial fulfillment of the requirements for the degree of doctor of philosophy. I would like to thank my advisor, J. David Smith, for his critical guidance and support throughout this project. Many thanks also to Joan Lucariello, William Hirst, and Jan Hawkins for their helpful comments and suggestions. I am grateful to the New School for Social Research for financial support of this work through a Ruth W. Berenda Dissertation Fellowship.

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